

Math with 0s



Nanocor®



Nanocor's technology can improve structural, temperature and barrier properties of many plastics. In addition to improving existing uses, nanocomposites made with Nanocor's clay have the potential to expand plastic

Polymer-Clay Nanocomposites - Better Plastics

Tie Lan

General Manager

Nanocor, Inc.

1500 Arlington Heights, IL 60004
USA



**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007



Outline

- **Plastic-Nanoclay Technology**
- **Commercial Applications**
- **Environmental Benefits**



**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007

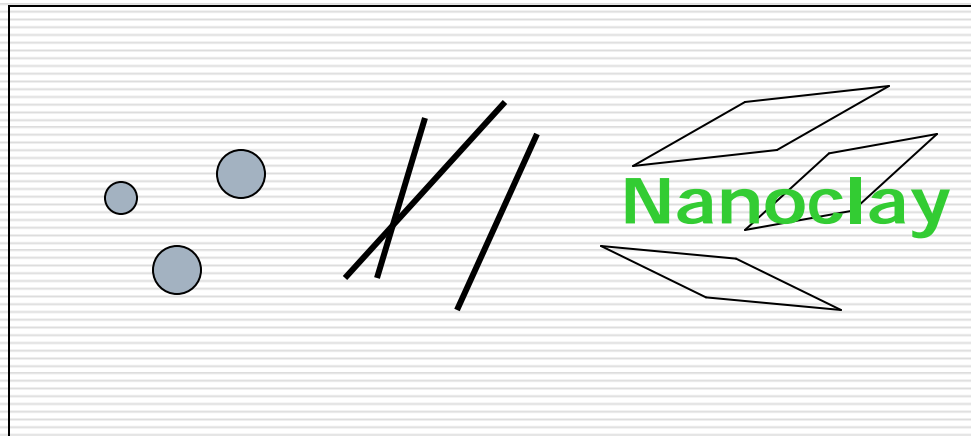


Nanotechnology

From composite to nanocomposite:

One continuous phase and at least one discontinuous phase

- At least one dimension in 100-nm scale

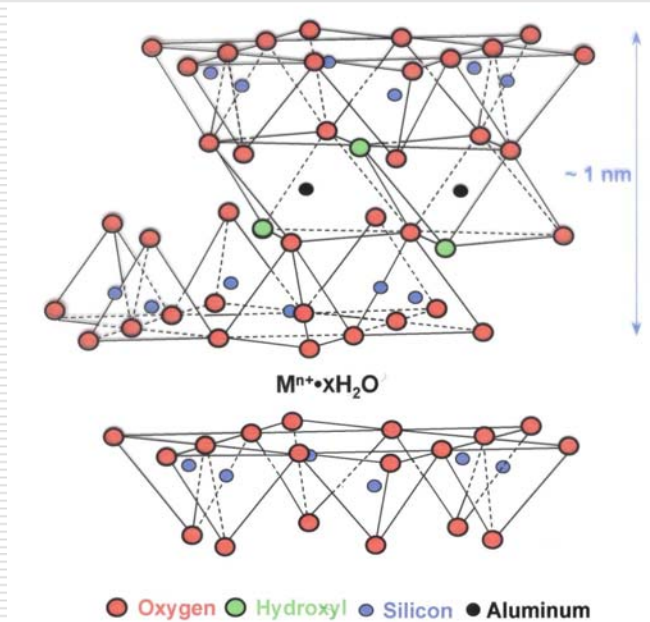


Nanocomposite Benefits

- **Mechanical properties improvement**
 - **Increase stiffness without loss of flexibility**
 - **Increased dimensional stability**
- **Enhanced barrier properties**
- **Chemical and thermal stability**
- **Flame retardation in combination with FR agents**
- **Easy processing and recycling**



Nanoclay



BENTONITE:

FDA 21CFR184.1155

GRAS: "Generally Recognized as Safe"

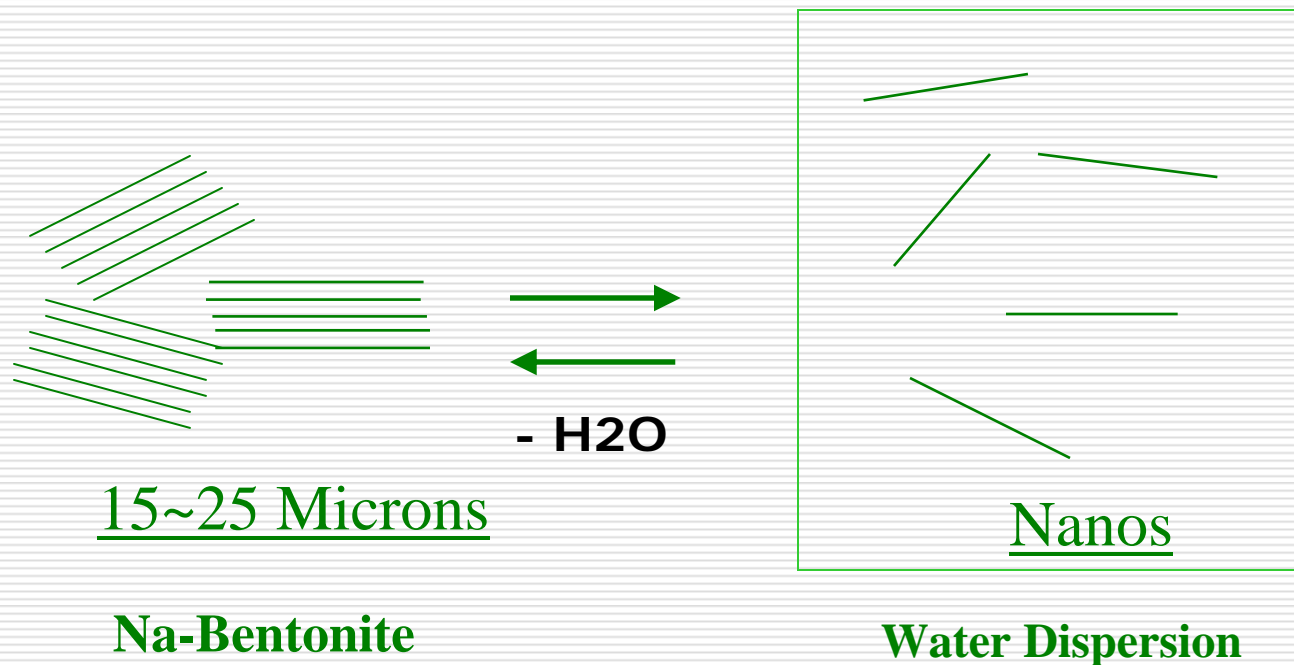
High aspect ratio

Silicate layers 200-300

Possible inner layer chemistry

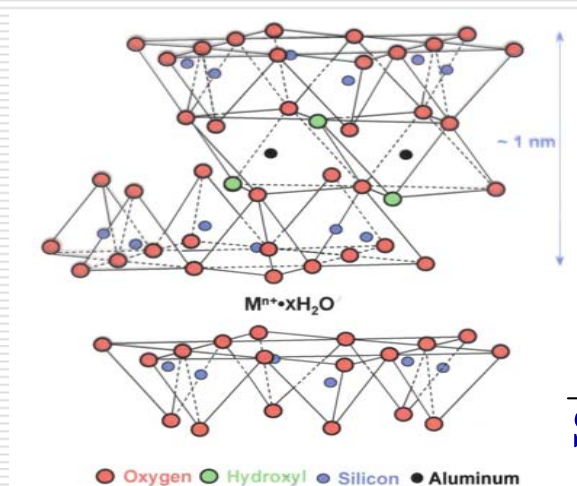
Nanoclay platelets are one-ten thousandth the diameter of a human hair!!

From Nanoclay to Nanocomposite

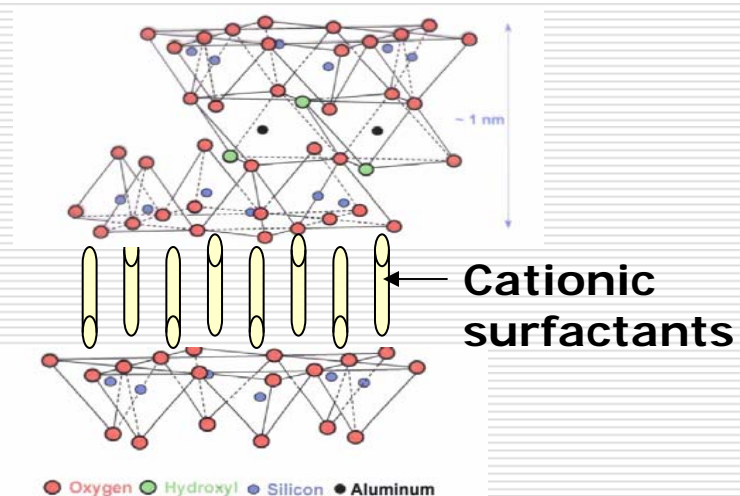


BEST DISPERSED NANOCCLAY

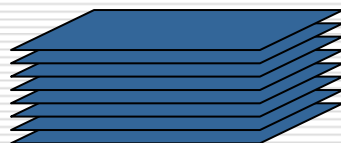
From Nanoclay to Nanocomposite



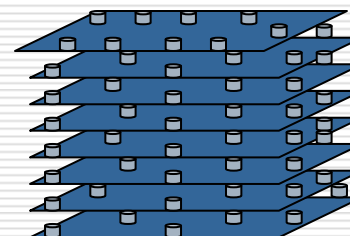
1st Step
Surface Treatment




Hydrophilic

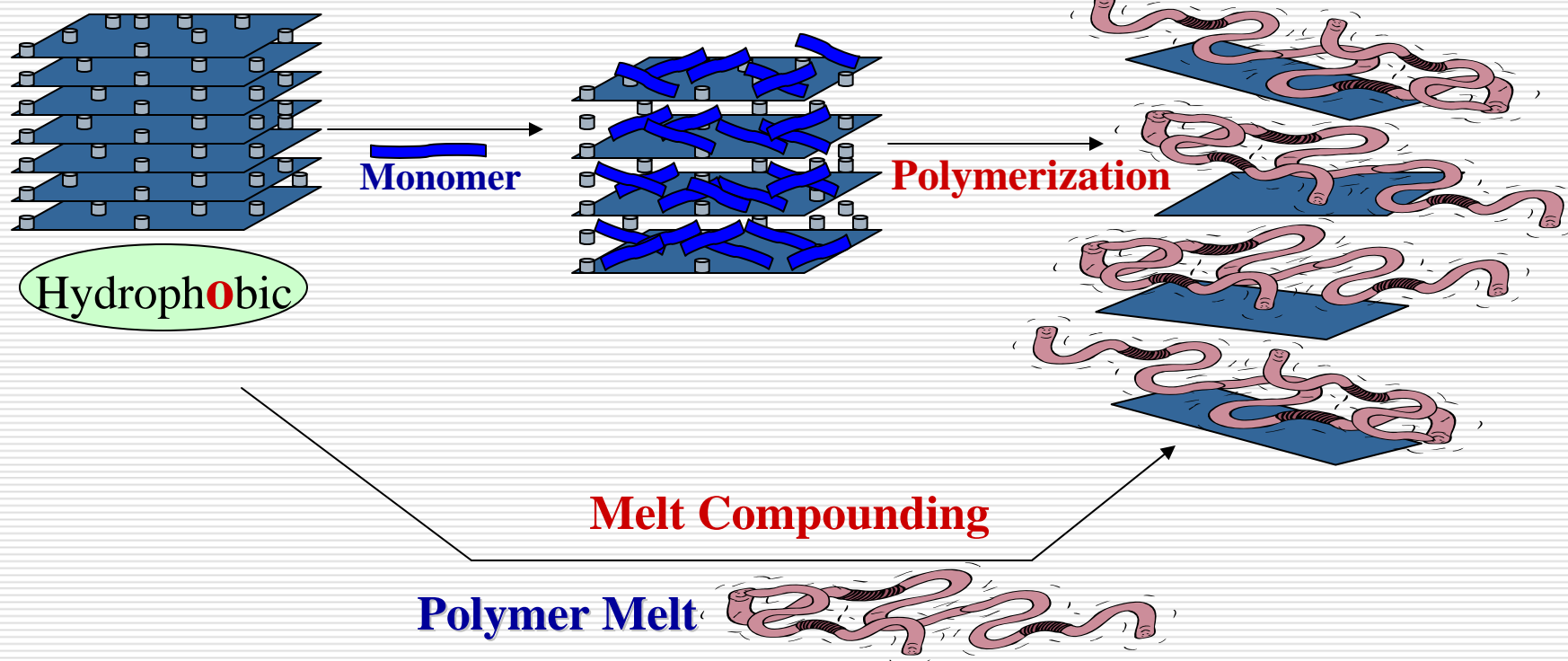


Hydrophobic



From Nanoclay to Nanocomposite

Nanomer®  Nanocomposite



From Nanoclay to Nanocomposite

nanoMax® Masterbatch Products



**Nanomer®
Powder**

Compatibilizer

**Polyolefin
Pellets**

**Twin Screw
Compounding**



nanoMax®

**Polyolefin
Pellets**

**Twin Screw
Compounding**

→ **Nanocomposite**

(Film, Engineering & FR)

**Single Screw Extruder
Injection Molder**

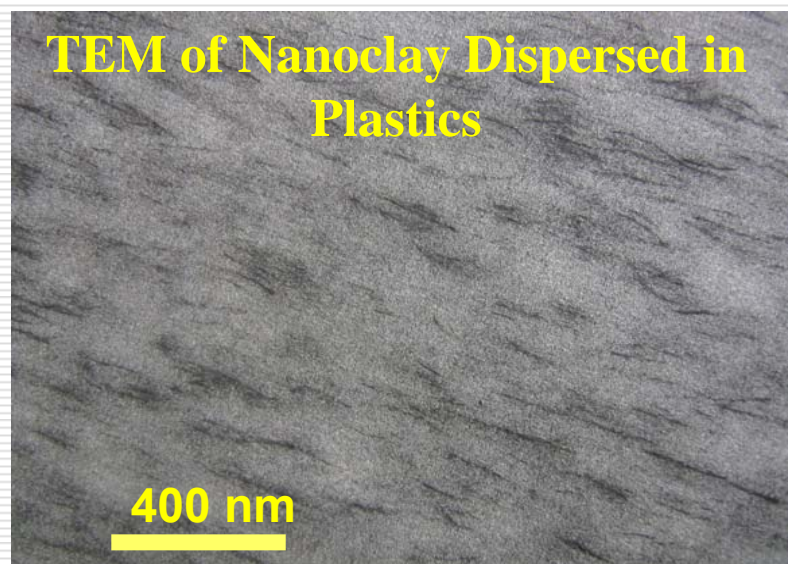
→ **Nanocomposite**
(Engineering, FR Only)



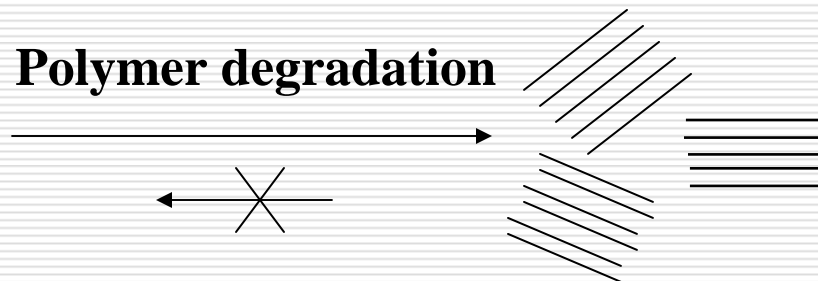
**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007



From Nanoclay to Nanocomposite



Polymer degradation

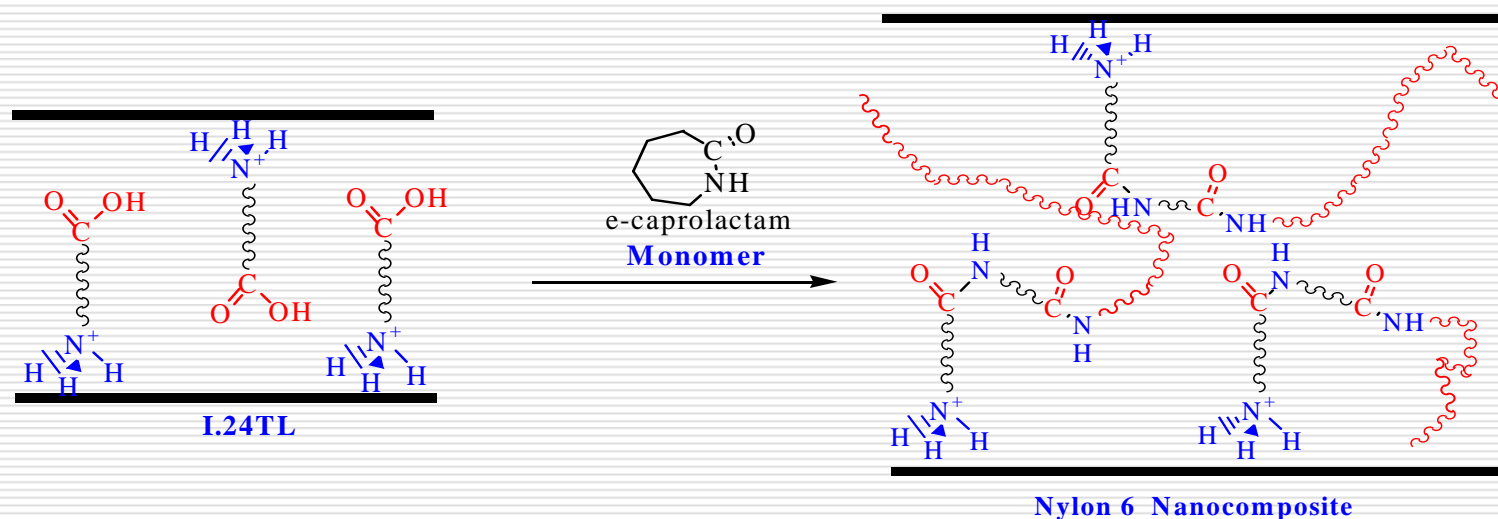


Nanoclay layers are encapsulated in the polymer only

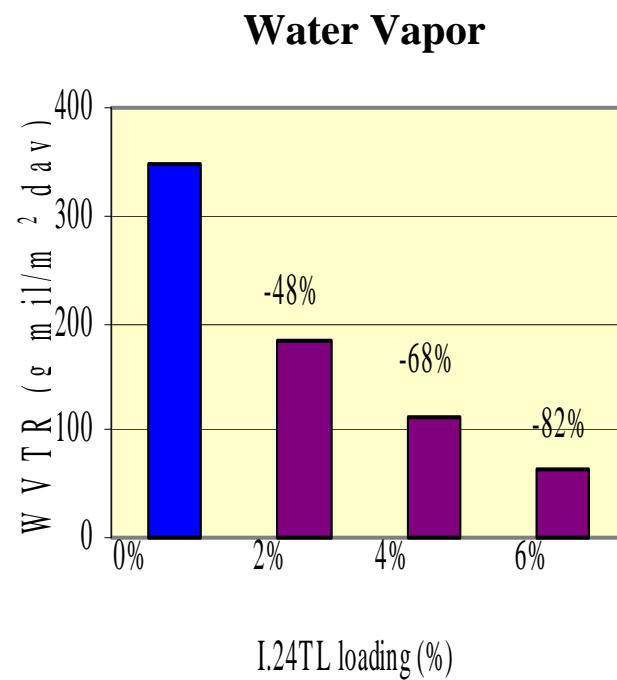
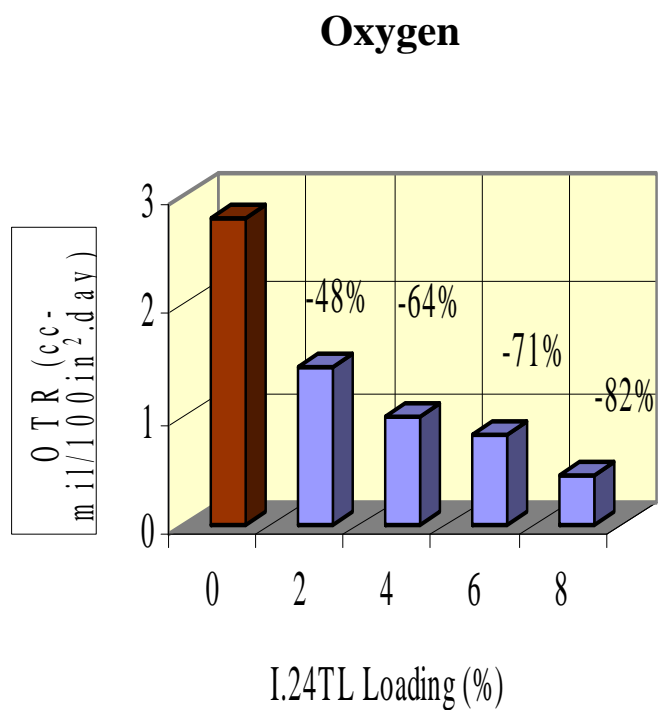
From Nanoclay to Nanocomposite

Nano-PA6

- In situ polymerization process with patented technology
- FDA/EU approval status for direct food contact



Barrier Improvement of nano-PA6



Film Mechanical Properties of Nano-PA6

Cast Monolayer Films (20-30 micron)

Flow Direction

Testing Sample	%Nano Loading	Young's Modulus (Mpa)	Yield Strength (Mpa)	Strain @ break (%)
Nylon 6 B135WP	n/a	150	12	700
Nano-PA6	3%	270	35	650

Perpendicular Direction

Testing Sample	%Nano Loading	Young's Modulus (Mpa)	Yield Strength (Mpa)	Strain @ break (%)
Nylon 6 B135WP	n/a	200	16	600
Nano-PA6	3%	380	28	550

Nanocomposites

- Same T_m, T_g ---Same processing
- Smart design

Use less resin ---same strength and barrier

PE//PA6//PE = 40//20//40

PE//nano-PA6// = 40//10//40

10% saving in film weight

Nanocomposites

Applications of Nano-PA6: Stand-up pouch

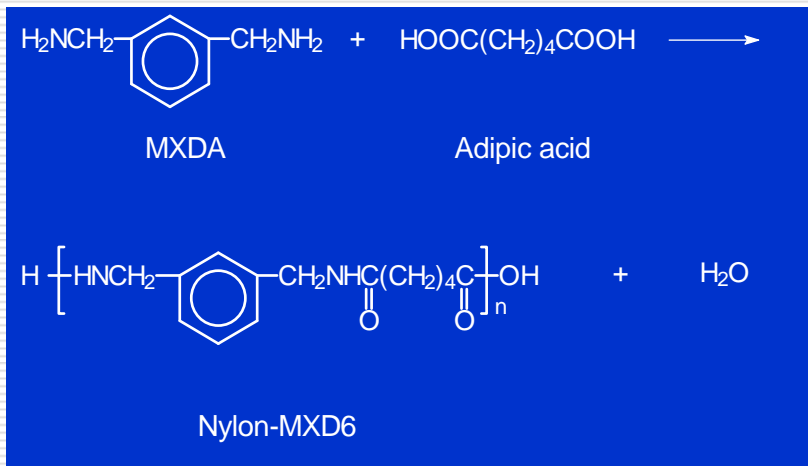


Nanocomposites

Imperm[®]

Superior gas barrier resin based on Nylon-MXD6

Nano-Nylon MXD6



Imperm® Barrier Properties

Property	Units	MXD6 ^{a)}	Imperm ^{a)}
OTR (23°C, 60%RH)	cc·mm/m ² ·day·atm	0.09	0.02
CO ₂ TR (23°C, 60%RH)	cc·mm/m ² ·day·atm	0.30	0.15
WVTR (40°C, 90%RH)	g·mm/m ² ·day	1.36	0.58

a) Non-oriented monolayer film



O₂ and CO₂ Sensitive Products



coca-cola-collection



Nanocomposites for Military Food Packaging



MRE Barrier Specifications:

$OTR \leq 0.06\text{cc/m}^2\text{-day-atm}$

$WvTR \leq 0.01\text{g/m}^2\text{-day-atm}$

Shelf Life = 3 Years at 80°F, 6 Months at 100°F

US ARMY NATICK SOLDIER RD&E CENTER. The Science Behind the Warrior: Yesterday, Today and Tomorrow

Objectives

- Eliminate Foil Layer in Meal Ready to Eat (MRE) Packaging
 - Capability of Microwave Processing, High Pressure Pasteurization, Radio Frequency Sterilization.
 - Reduction of Stress-Cracks and Pin-Holes
 - Reduce Processing Steps (No-lamination required)
- Decrease MRE weight
- Reduce Solid Waste

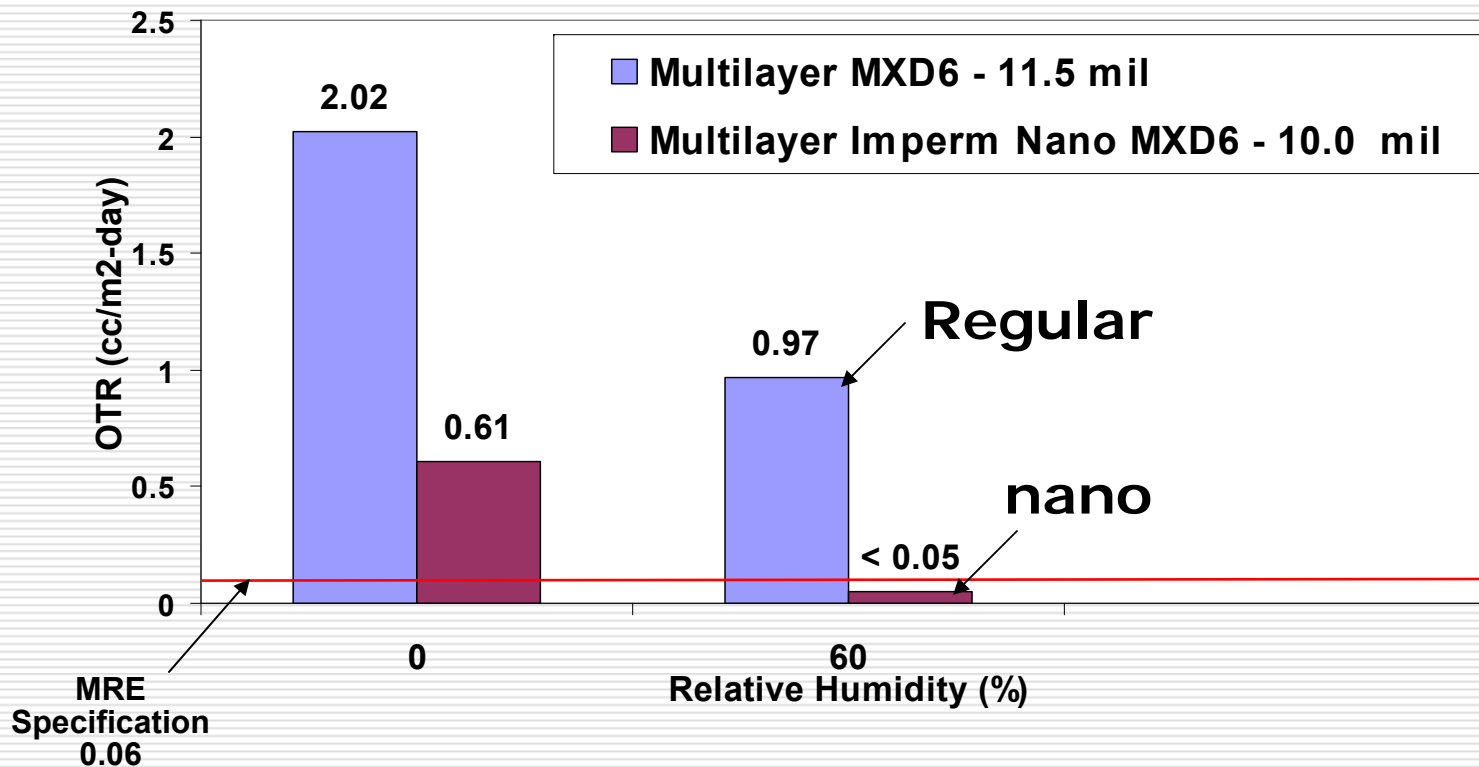


**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007



Nanocomposites for Military Food Packaging

Oxygen Transmission of Multilayer MXD6 and Imperm Films



US ARMY NATICK SOLDIER RD&E CENTER. The Science Behind the Warrior: Yesterday, Today and Tomorrow



P2 THROUGH
NANOTECHNOLOGY
SEPTEMBER 25-26, 2007



Nanoclay as FR Additives



Low Nanomer loading level

Reduction of Traditional FR Agents

Dripping Control

Anti-Blooming

Good Mechanical Properties

Easy Processing

Regulation Favorable

Nanoclay as FR Additives

- **Brominated systems**
Reduce toxicity
- **Metal Hydroxide-MDH, ATH**
Easy processing, high productivity
- **Intumescent systems**
Easy processing

Nanocomposite Applications

- **Wire and Cable Application**



Non-Hal, low smoke jacket
Slow burning
Low heat release rate

Nanocomposite Applications

- **Auto Parts**



Nano-PP replace GF Filled PP
25% weight reduction, easy processing



CP Polymer CRESS-ALON™ A Nano
Nano Resin
Brand name - Cress-Alon
Injection grade - NE2740, NE6040ST



nanoSEAL™ barrier resin



Nanocomposite Applications

- Marine Fuel Tank

ALUMINUM TANKS

For many years the boating community have used aluminum tanks but not without issues



A 1992 **Underwriters Laboratory** study on aluminum tank corrosion found the average service life for aluminum tanks is only **6.5 years**

Seaworthy magazine revealed that **8% of all boat fires** were caused by fuel leaks. While diesel fuel was an occasional culprit, 95% of fuel-related fires were caused by gasoline



Proprietary technology described herein is confidential and owned by Engineered Composite Solutions

In 2002 we had a two fold mission, one was to find an alternative to aluminum fuel tanks and second was to be first to market with a process that exceeds EPA directives of minimizing hydrocarbon emissions from fuel tanks in pleasure boats



Confidential and owned by Engineered Composite Solutions



Engineered Composite Solutions
provide a composite fuel containment system
for pleasure boats.



Nanocomposite Applications

ECS-FRP TANK DATA



NanoTank DATA

EPA TEST RESULTS FOR ECSI COMPOSITE FUEL TANK
Thu, 02 Oct 2003 13:13:34 -0400

US EPA tested the ECSI fuel tank at 85 F using 10% ethanol/90% Indolene test fuel. Permeation was determined through weight loss measurements over 2 weeks. Prior to testing, the fuel tank was set on soak at 80 F for 14 weeks with the same fuel blend (fresh fuel was used for the testing). The results were a permeation rate for the composite tank over the last 9 days was 0.67 g/m²/day. Fig 1 shows EPA proposed compliance baseline for permeation.

fig.1

Federal Register/Vol. 67, No. 157/Wednesday, August 14, 2002/Proposed Rules 53061

are presented in Table III C-1 because they represent an important parameter in defining the emission levels. The proposed fuel tank venting and permeation standards are based on the total capacity of the fuel tank as described below. The proposed hose permeation standards are based on the inside surface area of the hose. We are not proposing standards for hot soak and refueling emissions, as described above, at this time.

TABLE III C-1.—PROPOSED EVAPORATIVE STANDARDS

Evaporative emission component	Proposed emission standard	Test temperature
Dismal Venting	1.1 g/gallon-day	22.2-32.6 C (72-90 F)
Fuel tank permeation	0.08 g/gallon-day	40 C (104 F)
Hose permeation	5 g/m ² -day (15 g/m ² -day with 15% methanol blend)	23 C (73 F)

The proposed emission standards are based on our evaluation of several fuel system technologies described in Section III(H) which vary in cost and in the amount of the standards center

Clean Air Act section 213. An emission credit program can reduce the cost and improve the technological feasibility of achieving standards, helping to ensure the attainment of the standards center

met the proposed standards for dismal emissions. By using different combinations of these technologies, manufacturers will be able to produce products that achieve a range of

Using 10% Ethanol test fuel
ECS tank permeation was
measured at .047 g/g/day

nano

EPA rule requires no more
than .08 g/g/day

Notice the compliance standard for tank permeation was established in grams per gallon per day at .08/g/gal/test-day. The ECSI emissions test tank was one meter square inside and 14 gallons capacity, therefore .67 grams divided by 14 equals .047/g/gal/test-day.

Note:

USCG permeation tests on a 12 gallon rotationally molded cross-link polyethylene tank tested at 1.5/g/gal/test-day.

Regular

Current plastic tanks produce
Circa 1.5 g/g/day

CONFIDENTIAL

Nanocomposite Applications

- **Agriculture Film Application**

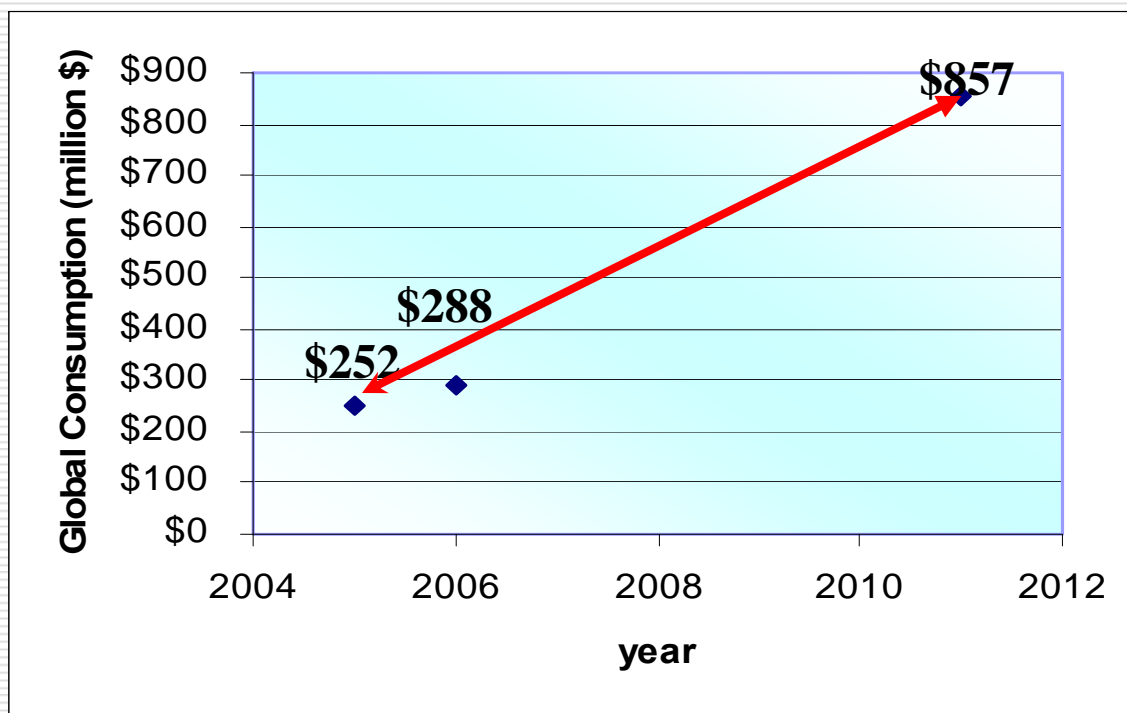


Reduce MeBr emission

Nanocomposite Market

Data Source: BCC Research
www.bccresearch.com

Global Consumption of Nanocomposites



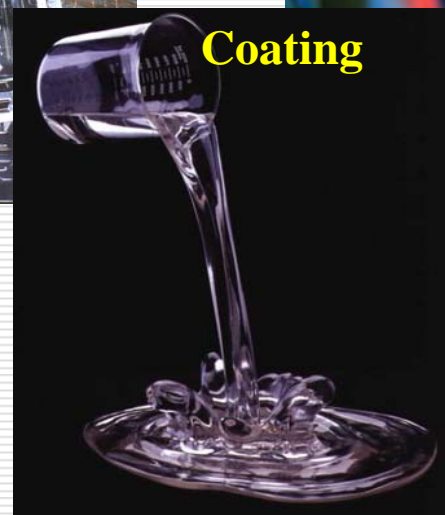
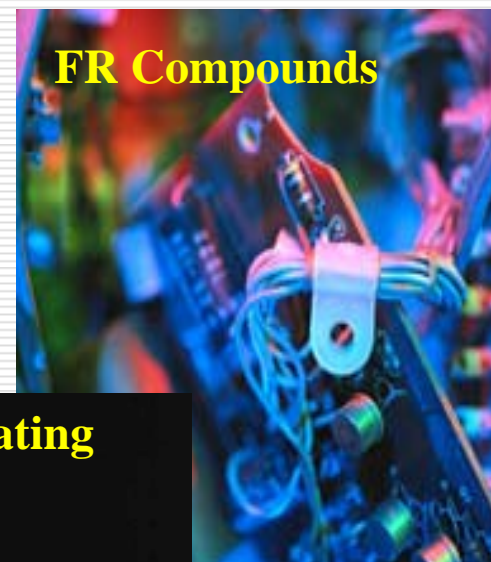
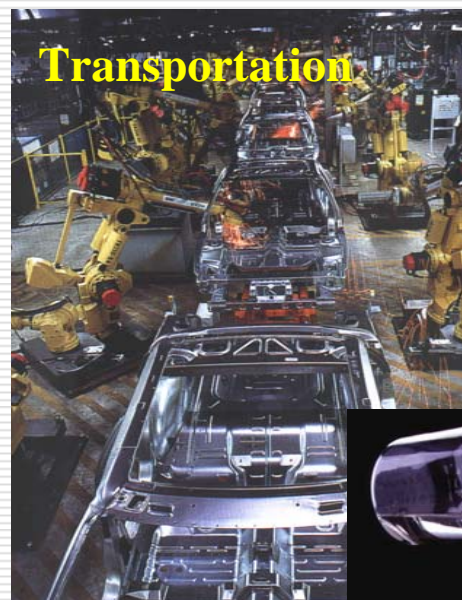
Average
Annual
Growth
Rate (AAGR)
24.4%



**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007



Nanocor Markets



**P2 THROUGH
NANOTECHNOLOGY**
SEPTEMBER 25-26, 2007



Summary

- **Nanoclays are effective additives to make better plastics**
- **Nanocomposite resins offer same processing and recycle**
- **Use of nanocomposite have good environmental impact**
 - **Lower weight auto parts**
 - **Less toxic flame retardant compounds**
 - **Thinner plastic package**
 - **Durable/impermeable fuel tanks**
 - **...**



Company Information



www.amcol.com (NYSE: ACO)

AMCOL International Corp., through its operating subsidiaries, is a leading international producer and marketer of value-added, specialty minerals and related products. The Company's products serve 12 major markets, including—metalcasting, detergents, pet products, building materials and personal care. AMCOL operates a transportation segment that acts as a servicing operation for other business segments and outside customers.

Headquartered in Arlington Heights, Ill., AMCOL operates 68 facilities in Asia, Australia, Europe and North America. The Company employs 1,750+ employees in more than 26 countries. The Company, established in 1927,



American Colloid



CETCO



HBS



Nanocor



Thank You

